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DRAWINGS ATTACHED

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(54) A MOULD FOR AND PROCESS OF FORMING CERAMIC PRODUCTS

(71) We, C. M. HUTSCHENREUTHER ZAHNFABRIK ZWEIGNNIEDERLASSUNG DER C. M. HUTSCHENREUTHER PORZELLAN AG, a German body corporate registered under German Law of Arzberg, Bavaria, Germany, do hereby declare the invention for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a mould for and a process of forming ceramic products.

The forming of shaped ceramic parts has hitherto usually been effected by pressing, throwing or casting. In these methods plaster moulds are almost exclusively used.

The effectiveness of these moulds depends upon the porosity of the plaster when his has set.

One defect of modern mass production methods is that because of their poor mechanical properties and the solubility of plaster in water the moulds have only a fairly short life. Another drawback is that dewatering of the shaped ceramic parts which proceeds in or on the moulds involves a considerable expenditure in moulds and machines because of the poor resistance of plaster to heat.

Many attempts have therefore already been made to overcome these defects by improving the mechanical and thermal properties of the plaster used for making the moulds.

Additions of cellulose derivatives, polyvinyl alcohols and acetates, lime and cement as well as of synthetic plastics materials based on epoxy, polyester and methacrylate resins have been proposed. However, since these additions for improving mechanical properties of the plaster also adversely affect its porosity, they have not been a success in actual practice.

It has also been proposed to make moulds for forming ceramic parts from materials other than plaster.

For example, German Patent Specification ("patentschrift") No. 1 127 787 describes a material for the production of moulds which consists of a highly fired ceramic mass rich in clay products and containing some fluxes, and the published specification of German ("auslegesschrift") No. 1 241 751 relates to a method of producing moulds based on inorganic filler materials in association with organic binders. However, even these methods have not proved successful in practice because the firing process leads to shrinkage and more particularly to distortion of the moulds and the above-mentioned specification comments on the considerable difficulties encountered in the development of the necessary pore system.

It is a primary object of the present invention to overcome the defects of the hitherto practised methods of forming plastic ceramic masses by forming the plastic ceramic mass in an injection moulding process and dewatering the mass through a porous wall structure of the mould. The essence of the invention resides in using an injection moulding technique in conjunction with moulds of satisfactory porosity. Preferably the moulds are also heat-resisting.

It is preferred to make these moulds from inorganic filler materials in a binder formed from synthetic resins of a particular group. Filler materials suitable for the purpose of the inventinon are any sustances which conduct heat, and which can be prepared in grain sizes between 0.005 and 0.5 mm. In practice metal powders, such as powdered aluminium and/or copper are used.

The binders for producing a mould according to the invention are any synthetic resins which evolve a gaseous phase at the temperature of setting. In practice it is preferred to employ polycondensation resins, such as phenolic, melamine and urea resins.

The capillary system which is essential to

the effectiveness of the moulds must have continuous open-ended pores traversing the thickness of the material and formed by the evolution of the gaseous substances during the process of setting of the resin.

It has proved advantageous to include in the compositions employed for making the moulds according to the invention a proportion of the above specified synthetic resin binders between 5 and 35%. The binders should be in a liquid or pulverulent form or in a mixture of both. The binders may be hot or cold setting with or without the application of pressure.

The mass production of ceramic mouldings by injection moulding in porous heatable moulds has the advantage that the ceramic mouldings can be very quickly dewatered.

On the one hand a stationary upper part of a mould may be adapted to co-operate with a plurality of heated bottom parts of moulds on an indexable table to close each of the bottom parts only during the process of injection, so that after the mouldings have been formed they can be dewatered to leather hardness within 60 seconds by heating the bottom mould halves and additionally admitting hot air, preferably from above.

Alternatively the injection moulded parts may be dewatered by suitably increasing the pressure directly above the developed pore system of the mould, the build-up of pressure being effected by the pressure generating means of the injection moulding machine transmitted by way of the injection moulded mass itself.

Additional heating of the moulds in this procedure results in the ceramic mouldings being ready for ejection from the moulds in a leather hard state after as short a time as a few seconds.

For large scale production the first mentioned method of drying requires an upper mould part as well as up to 15 bottom mould halves, whereas the second method of dewatering permits the production of ceramic mouldings to proceed in a single working mould. In both methods simple plunger type machines are entirely suitable for the injection moulding process and the plastic ceramic mass may be injected cold, i.e., at room temperature. In the ceramic industries this technique, which is the first to propose the use of heated moulds for dewatering ceramic mouldings, constitutes a very substantial step forward in the art. Compared with conventional forming methods the number of moulds required is considerably less, bearing in mind that at present it is usual to use 1500 to 3000 moulds in a set. Additional economies arise in connection with the replacement of moulds as well as in the handling, transportation and storage of moulds.

By producing ceramic parts by injection moulding the drying devices hitherto required for drying to leather hardness as well as the hitherto necessary dressing and cleaning off are eliminated.

Moreover, the consumption of ceramic mass is reduced by as much as 40% compared with modern throwing techniques, since forming by injection moulding eliminates the necessary excess of plastic mass required for throwing. An important advantage of the injection moulding technique resides in that it also permits parts to be produced that cannot be thrown or jiggered and that hitherto had to be cast.

In another development of the proposed method of producing shaped ceramic parts, it is proposed not only to use heated moulds but in addition also to heat the plastic mass itself prior to moulding. It has been found that it is useful to heat the moulding mass to between 40 and 140°C, preferably to between 70 and 95°C, before it is injected into the mould.

According to one important embodiment of the invention the plastic ceramic mass is moulded in an injection moulding machine of the screw press type and the moulding mass is at least partly preheated in the machine.

The advantages that can thus be achieved are very significant. These already arise in the preparation of the plastic mass. Whereas hitherto special machines had to be provided for homogenising and deaerating the mass in a separate operation, the mass as obtained from the filter press or from the kneading operation can be directly processed by the method according to the invention. Moreover, the hitherto necessary and very costly preparation of the masses in a vacuum press can also be dispensed with.

According to the invention—and this is yet another major advantage—the water content of the plastic masses that are to be moulded can be kept substantially lower than in hitherto conventional processing methods because the steam cushion which forms when the water-plasticised injection moulding mass is heated ensures a fully satisfactory degree of flowability for forming, even when the water content of the mass is only about 15%. Hence the mass used for injection moulding according to the invention is processed with a water content between 10 and 20 percent by weight and preferably between 14 and 18 percent by weight.

The proposal to use moulding masses that are heated prior to moulding may be performed, as above-mentioned, by heating the mass in a screw injection press. In such a press a considerable proportion of the required thermal energy can be provided by

the heat of friction generated during plastification.

Another very important advantage of the invention is that dewatering of the ceramic shaped products is much more rapid. Dewatering already commences during the actual moulding process since the steam contained in the preheated injected mass can escape through the pores of the mould. Consequently the mouldings can be taken out of the mould in a leather hard state directly after they have been moulded.

Another significant advantage of the invention is that for producing ceramic mouldings from plastic ceramic masses by the injection moulding technique only a single working mould is required.

A further advantage that should not be under estimated is that, in this method, densification of the mass in the mould is much higher, with a consequent improvement in quality.

Vacuum de-aeration prior to injection, of the plastic ceramic mass, is not essential.

Besides the advantages that have already been mentioned, the invention also has the advantage of permitting complicated ceramic shapes to be produced in a single operation. This applies more particularly, though not exclusively, to the production of cups. In the production of cups the proposed method eliminates the necessity of producing the body of the cup and the handle in separate operations. A cup formed with a handle can be produced in one operation.

The invention is illustrated by way of example in the drawing, in which:—

Fig. 1*a* is a sectional elevation of a closed injection mould, and

Fig. 1*b* is a diagrammatic view illustrating the drying of the injection moulded part, and

Fig. 2 is a sectional elevation showing another method of drying the moulding.

Referring to the drawing, a ceramic moulding 1 is shown inside a mould consisting of a porous bottom part 2, an upper part 3 and a sprue 5 for injecting the mass. Both the upper part 3 and the lower part 2 of the mould contain heating elements 4 and 4'. As shown in Fig. 1*b*, when injection has been completed the upper part of the mould 3 which serves to close a plurality of lower parts 2—all the lower parts 2 being supported, for example, on an indexable table—is removed and the lower part 2 containing the moulding 1 is taken to a drying device 6 for drying the moulding, in which hot air is blown on the moulding from nozzles (see the arrows). The moulding is thus dried to leather hardness in a very short period of time.

In Fig. 2 the moulding 1 is dried by the application of pressure which forces the moisture through the pores in the bottom part 2 of the mould. The pressure may be transmitted by the mass itself through the sprue 5. The discharged moisture collects in a channel 7 through which it is withdrawn.

A mould as described above, suitable for use in the process according to the invention may be formed by moulding from a composition having the following constitutents:—

400 gm of copper grain size 100-120/u
2250 gm of aluminium powder „ 40- 60/u
270 gm of a liquid phenolic resol
360 gm of a solid phenolic resin based 1276731—GALLEY TWO on novolac hexamethylene tetramine in powder form.

After mixing together the constitutents of the composition, it is moulded in a hydraulic press and is set by subjecting it to heat.

WHAT WE CLAIM IS:—

1. An injection mould for the production of a moulded dewatered ceramic mass, at least part of said mould being formed of a heat-conducting material, comprising an inorganic metal filler material bound in a synthetic resin and having a porous structure comprising a capillary system produced by means of a gaseous phase evolved by the resin during setting thereof.

2. An injection mould as claimed in Claim 1, in which the heat conducting inorganic metal filler comprises a powder having a grain size of from 0.005 mm to 0.5 mm.

3. An injection mould as claimed in Claim 2, in which the metal powder is copper and/or aluminium.

4. An injection mould as claimed in any one of Claims 1 to 3, in which the synthetic resin binder comprises a polycondensation resin.

5. An injection mould as claimed in Claim 4, in which the synthetic resin binder includes a phenolic, melamine or urea resin.

6. An injection mould as claimed in any one of Claims 1 to 5, in which the proportion of resin binder in the composition forming said mould is from 5 per-cent to 35 per-cent.

7. An injection mould as claimed in Claim 1, substantially as described herein and as shown in the accompanying drawing.

8. A process for the production of a ceramic product wherein a plastic mass is injected into an injection mould as claimed in any preceding claim and the moulded product is dewatered through the capillaries of said mould.

9. A process as claimed in Claim 8, wherein the moulded product is dewatered and dried to a leather hardness by heating the injection mould and additionally subjecting the moulded product to treatment with hot air.

10. A process as claimed in Claim 9, wherein the injection mould is opened prior to dewatering the moulded product, to expose a face of the latter whilst leaving the remainder supported in a part of the mould having a porous wall structure, and the product is dewatered by heating said porous part of the mould and blowing hot air upon the exposed face of said product.

11. A process as claimed in Claim 8, wherein the moulded product is dewatered and dried to leather hardness by heating the injection mould and subjecting the moulded product to pressure.

12. A process as claimed in Claim 11, wherein the moulded product is subjected to pressure by way of the plastic ceramic mass in the sprue of the mould.

13. A process as claimed in any one of Claims 8 to 12, wherein the plastic ceramic mass is preheated prior to injection into the mould.

14. A process as claimed in Claim 13, wherein the plastic ceramic mass is preheated to a temperature of from 40°C to 140°C.

15. A process as claimed in Claim 14, wherein the plastic ceramic mass is preheated to a temperature of from 70°C to 95°C.

16. A process as claimed in any one of Claims 13 to 15, wherein the plastic ceramic mass is injected into the mould by means of a screw press serving to effect at least partial preheating of the mass due to heat generated by friction.

17. A process as claimed in any one of Claims 8 to 16, wherein the plastic ceramic mass injected into the mould has a water content of from 10 per-cent to 20 per-cent by weight.

18. A process as claimed in Claim 17, wherein the plastic ceramic mass injected into the mould has a water content of from 14 per-cent to 18 per-cent by weight.

19. A process as claimed in any one of Claims 8 to 18, wherein the plastic ceramic mass is injected into the mould without prior vacuum de-aeration.

20. A process as claimed in Claim 10, substantially as described herein.

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1276731 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

Fig. 1a

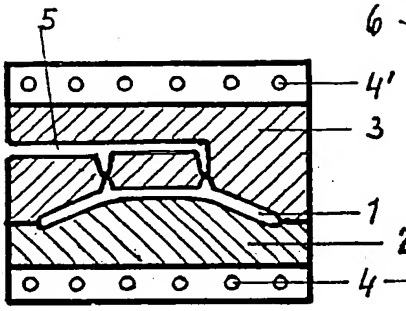

Fig. 1b

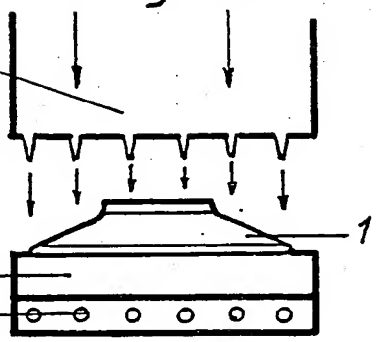

Fig. 2